UTILIZATION OF SUNFLOWER STALKS IN PAPER MANUFACTURE

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The utilization of sunflower
stalks in paper manufacture

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THE UTILIZATION OF SUNFLOWER STALKS

IN

PAPER MANUFACTURE.

A THESIS

Presented by

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to the

President & Faculty

of

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for the

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Having Completed the Prescribed Course of Study

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P R E F A C E.

Part I.

The object of this part is to determine the most efficient cooking of the sunflower stalks, and beating and bleaching of the pulp, and all other experimental data connected with the process.

Part II.

This chapter deals with the proposed process and giving an idea of the cost of operation.

Part I.

1. Introduction.
2. Treatment -
    a. Cooking.
    b. Beating.
    c. Bleaching.
    c. Sizing.
3. Making of Sheets.
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5. Samples of paper made.
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Part II.

1. Process.
2. Cost.

PART I.

The Object of this part is to determine the most efficient cooking of the sunflower stalks, and beating and bleaching of the pulp, and all other experimental data connected with the process.

THE UTILIZATION OF SUNFLOWER STALKS IN PAPER MANUFACTURE.

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The object of this work is to determine whether the sunflower stalks could be economically used in the manufacture of various grades of paper. The two grades of sunflower stalks; the green stalks,(stalks cut while still green), and the natural dried stalks,(stalks cut after having started to dry), which were used in this work were obtained from Kansas. The green stalks upon arrival were dried in a steam heated closet. The sunflower stalks were cut into small chips, each variety being kept separate. The chips were divided into four groups and each group was separately treated.

Cooking of the Sunflower Stalks.

The four groups of sunflower stalks were as follows:

Group I. Consisted of green sunflower stalks; chips with the pith of the stalks removed.

Groups II and III. Consisted of natural sunflower chips with the pith of the stalks.

Group IV. Was made up of natural dried stalks with the pith removed.

The leaves of the green stalks which were dried in the dryer were removed and then the stalks were cut open and the pith removed. The stalks, after the removal of the pith, were cut up into chips of about two to three inches in length and 1/8 inch to 1/4 inch thick. .55 lbs.of chips were placed into the cooker capable of holding three liters. The stalks were covered with liquor of the following content:

$NaOH$	- 4% of wgt.of stalks used	.....12 grs.
Na_2CO_3	-12% " " " " "	.....35 " .
$NaCl$	-10% " " " " "	.....29 " .
$NaOCl$	-0.5% " " " " "	.....1.5 " .

The liquor was made by diesolving the above substances in one liter of distilled water. Then water was added to the mixture in the cooker until the chips were well covered with water. The cooker was closed and heat was applied to it by the use of a Bunsen burner flame. The pressure in the cooker during this run was maintained at 90 to 100 lbs. per square inch. The run was made in two periods of five hours each, as it was impossible to make a ten hour run on the same day. As soon as the cooker was cold enough so that it could be easily handled, the chips were removed from it by taking off the cover and in-

verting the cooker. The chips were washed with water. The washings and the cooking liquor were saved for the determination of the recoverable alkali. The chips were now ready to be beaten in the pebble mill.

The leaves of the natural dried stalks were removed and the stalks with the pith were cut up into chips of the same size as for the previous run. Twelve ounces of these chips were placed into the cooker and used for the second run. The cooker was filled up as before, but the cooking liquor was changed to the following composition:

$NaOH$	- 3% of wgt.of stalks used	.....	10.23 grs.
Na_2CO_3	- 15% " " " " "	.....	56.96 " .
$NaCl$	- 8% " " " " "	.....	27.28 " .
$NaOCl$	- 0.25% " " " " "	.....	.85 " .

The stalks were cooked at a pressure of 70 lbs.per square inch for thirteen hours. The run was made in two periods; the first in nine hours and the second in four hours. At the completion of the run the liquor was drained from the stalks and saved for later use. The cooked stalks were weighed and the moisture content was determined.

The third run was performed on the same stalks as the second . $7\frac{1}{4}$ oz.of chips were placed into the cooker and the fol-

lowing cooking mixture was added:

$NaOH$	- 3% of wgt.of stalks used	.....	6.15 grs.
Na_2CO_3	- 9% " " " " "	.....	16.4 " .
$NaCl$	- 5% " " " " "	.....	10.25 " .
$NaOCl$	- .25% " " " " "	.....	.513 " .

1.36 liter of cooking liquor obtained in the second run.

The material was cooked for nine hours in two periods; one of five hours and the other of four hours, and at a pressure of 120 lbs. per square inch. At the end of the run the liquor was drained from the chips and the chips were weighed and placed into the beater. The liquor was saved for further use.

The fourth run was performed on natural dried sunflower stalks from which the pith was removed. The cooking liquor was changed. The following cooking mixture was used with 10½ oz.of sunflower stalk chips:

$NaOH$	- 5% of wgt.of stalks used	.....	14.7 grs.
Na_2CO_3	- 12% " " " " "	.....	35.1 " .

One (1) liter of cooking liquor from the third run was also added. The mixture was cooked for fourteen hours in periods of eight and six hours. The pressure was maintained at 80 lbs.per square inch. The liquor was drained from the chips and saved for analysis and recovery of alkali.

Beating of Cooked Sunflower Stalks into Pulp.

The cooked sunflower stalks of the first run which have been washed free from alkali were divided into three equal portions. Each portion was placed into a jar and each jar was filled one-half full with pebbles, which were more egg shaped than spherical. The content in the jar was covered with water and then the jar was closed. The jars were placed upon the frame and revolved about their longitudinal axis. The jars were revolved until the pulp when suspended in water showed individual fibres. The jars had to be revolved for twenty-four hours before this stage of beating was reached. The content of each jar was now poured into a large jar and the pebbles were washed free from fibres. The water with the sunflower stalk fibres is poured on a towel and drained from fibres. The fibres or pulp was weighed and the moisture content determined.

The cooked chips of the second run were divided into three equal portions and placed into jars as those of the first run. The material was beaten for ten hours and then poured on a ten-mesh sieve and the fine pulp was washed from the pebbles and from the unbeaten stalks. The unbeaten stalks were replaced into a jar, half filled with pebbles, and the beating was continued for thirty hours. The mixture was again poured on a ten-mesh sieve and the fibres washed from the pebbles and the unbeaten stalks. The washings containing

the fibre of the sunflower stalks were poured on towels and the water drained from the fibres. The residue or pulp on the towels was weighed and the moisture determined. The unbeaten stalks were dried at 105° and weighed.

The cooked chips of the third run were divided into two equal portions and beaten for twelve hours. The mixture from the jars was poured on a ten-mesh sieve and the pebbles and the unbeaten chips were washed free from pulp. The water with the suspended pulp was poured on a towel and the pulp separated from the liquid. The mixture of the pulp was determined. The unbeaten chips were removed from the pebbles, dried at 105°C. and weighed.

As the time was short, the chips could not be beaten further, in order to have any result by the time this report had to be completed. Therefore, the chips were not beaten as much as those of the previous run.

The cooked chips of the fourth run were divided into three equal portions and placed into three jars as those of the first run. After having run the beater for three hours to one jar, 50 grams of $KMnO_4$ were added, and the mixture beaten up for two hours longer. To the third jar, 100 grams of $KMnO_4$ were added, and the jar replaced on the frame and the material beaten up for two hours longer. The content of the second jar was poured after seven hours of beating

on a ten-mesh sieve and then it was removed from the pebbles and stalk chips as in the previous runs. The bleached pulp of the first and third jar was treated in the same manner, only that there were no unbeaten stalks present. The moisture was determined on the pulps obtained.

Bleaching of the Pulp.

A definite amount of pulp from the first run was diluted with a liter of water. Chlorine gas, which was generated by MnO_2 by reacting with HCl was passed into the beaker containing the diluted pulp until the pulp was fairly white.

The color of the bleached pulp was good, but the fibres were destroyed to such an extent that it was impossible to mat them on the screen. This method of bleaching was not employed in bleaching the pulp of the other three runs.

The second method of bleaching that was tried was the bleaching with bleaching powder. The powder was dissolved in water and the solution filtered. The clear filtrate was gradually added to the pulp in beaker. The pulp for bleaching was prepared as that for chlorine gas bleaching. Samples were taken at different stages during the bleaching of the pulp. This was done to see the effect the bleaching powder has upon the pulp, as it bleaches from dark brown to yellow white. This method of bleaching was also tried on the pulp of the second and third run.

The third method of bleaching tried was that of dry chlorine gas. The water was squeezed from the pulp until the pulp was fairly dry. The dry mass was placed into a flask filled with chlorine gas. The flask was stoppered and well shaken to loosen up the fibres and then it was allowed to stand over night. A part of the fibres turned to a yellowish color while most of them formed small dark lumps which were hard to break up. This method of bleaching was not tried on the subsequent runs.

The fourth method of bleaching that was tried was the one using $KMnO_4$ as the bleaching agent. The pulp was prepared as for chlorine gas bleaching. The solution was heated and the $KMnO_4$ was gradually added to the warm pulp mixture in the beaker. Samples were withdrawn to show different stages of bleaching and the effect of $KMnO_4$ upon the fibre. $KMnO_4$ was added until the solution remained violet on heating. H_2SO_3 was added to the bleached pulp to remove the excess of the bleaching agent and the MnO_2 formed from $KMnO_4$ during the bleaching of the pulp. The bleaching of the pulp of the second, third and fourth runs differed from this method in that to a definite amount of pulp a definite quantity of powdered $KMnO_4$ was added.

The fifth method of bleaching, which was tried upon the pulp of the second and third runs was that of bleaching powder followed by $KMnO_4$. To a definite quantity of pulp a definite amount of bleach-

ing powder solution was added. The mixture was heated for fifteen minutes and then a definite amount of powdered $KMnO_4$ was added. The mixture was heated until the violet color of the solution had disappeared, and then H_2SO_3 was added until all of the MnO_2 was removed.

The sixth method of bleaching was that of combining bleaching and beating of the pulp. The cooked chips were beaten for a definite time, then to the pulp a known quantity of $KMnO_4$ was added, and the mixture was beaten for a few hours longer. This method was tried on cooked chips of the fourth run.

The Sizing of the Pulp.

The rosin and aluminum-sulphate sizing was made according to the following composition:

The rosin was saponified with 16 percent sodium-hydroxide. $Al_2(SO_4)_3$ solution was made so that 1 c.c. of the solution contained 10 percent of $Al_2(SO_4)_3$ by weight in terms of rosin solution. That is - 10 c.c. of rosin solution contained 1 gr. of rosin and .16 gr. of NaOH and 10 c.c. of aluminum-sulphate contained .116 gr. of $Al_2(SO_4)_3$. The two solutions constitute one sizing. The amount of sizing used in experiment was 5 percent of the weight of the pulp. The required amount of rosin solution was added to the pulp and then the pulp was well mixed. As soon as the pulp and rosin solution were thoroughly

mixed the required amount of $Al_2(SO_4)_3$ was added, and the solution again well mixed. Immediately after mixing, the pulp was poured upon the screen to make sheet of paper.

The albumin (white of egg) was dissolved in cold water and to it were added a few drops of concentrated solution of NaOH. This gave another sizing and it was used in the same ratio as the previous sizing.

Making of Sheets from Pulp.

The screen which holds the fibres and allows the water to pass through, is mounted on the lower half of the box. When the two portions of the box are placed together the screen is in the center of the box. The box is placed into a large pan containing water, so that the surface of the water stands about onehalf inch above the screen. Enough pulp to make a sheet of paper was placed into a beaker and diluted with water. This was poured upon the screen. The box with the screen was gradually raised and during the raising was given a shaking motion to make a uniform sheet and to mat the fibres thoroughly. When the water was sucked through, the upper portion of the box was removed. The pulp had formed a sheet of paper and was on the screen. A blotting paper was placed on top of the sheet which was formed; then the box was inverted and the screen pressed down with the hand. The pressing

down of the screen caused the sheet of paper to part from the screen. The sheet of paper on the blotting-paper was placed under a number of blotting papers, and pressed by placing fifty pounds of iron upon it. The wet blotting papers were replaced by dry ones until the sheet of paper was dried. Each sheet formed was tested with the Mullen tester for strength.

The Mullen paper tester is a device which exerts and records the pressure required per square inch to tear the paper.

DATA AND RESULTS.

First Run:

Weight of stock used (including moisture) ----------.55 lbs.

Determination of moisture:

Weight of crucible and stock : --------	13.7811 gr.
" " " :	12.5821 gr.
Weight of stock:	1.1990 gr.

" " crucible, stock & moisture ----------13.7811 gr.

Weight of crucible & stock after heating at 105° C. for 3 hours: ----------13.6585 gr.

Weight of Moisture: ---------- .1226 gr.

$$\frac{.1226}{1.199} \times 100 = 10.2\ \%$$ moisture in stock.

Obtained 1.67 lbs. of Pulp.
Moisture in Pulp.

Weight of crucible and wet pulp ----------	15.2260 gr.
" " " :	12.4228 gr.
Weight of Wet pulp: ----------	2.8032 gr.

Weight of crucible, pulp & moisture : ------	15.2260 gr.
" " " & pulp after drying for 3 hours at 105° C. ----------	12.8007 gr.
Weight of Moisture: ----------	2.4253 gr.

$$\frac{2.4253}{2.8032} \times 100 = 86.5\ \%$$ moisture in pulp.

Yield of Pulp.

Dry stock -----	55- (.102 x .55) =	.494 lbs.
Dry pulp	1.67- (.865 x 1.67) =	.22 lbs.

$$\text{Yield} = \frac{.22}{.494} = 44\ \%.$$

Alkali Recovery.

Total volume of liquor = ---------- 7300 c.c.

2000 c.c. of liquor evaporated and ignited. The ignited mase was taken up with water and diluted to 500 c.c.

50 c.c. of this solution were neutralized by 99.8 c.c.HCl.

1 c.c. HCl = .00339 gr. HCl.

$$\text{Wgt. of } Na_2CO_3 = \frac{Na_2CO_3 \times 99.8 \times .00339}{2\ HCl} = .49 \text{ grams.}$$

10 x .49 x 3.65 = 17.89 grams.

$$\frac{17.89}{35} = 51\ \%\ \text{recoverable } Na_2CO_3 .$$

Titration for NaCl by $AgNo_3$ showed that there was 5% of NaCl recoverable.

Strength of Sheets.

The percent of strength as used in the following tables was calculated as follows:

Sheet No.1 was torn when 30 lbs.per sq.in.were applied.

The thickness of sheet was .12 mm.

Then: .12 x .03939 = .0047268 inch.

$$\frac{30}{.47268} = 63.5\ \% .$$

Sheets from the First-Run Pulp bleached with $KMnO_4$.

No.	Kind of Sheets.	Lbs. per Sq.In.	Thickness. mm	Per-cent Str.
1	Sheet from pulp as it came from beater:	30	.12	63.5
2	Fibre of #1 bleached with $KMnO_4$:	50	.18	70.5
3	Fibre of #2 " " more $KMnO_4$:	50	.13	98.0
4	Fibre of #3 " " " $KMnO_4$:	27	.08	86.0
5	Fibre of #4 " " $KMnO_4$ until solution was violet:	47	.15	80.0
6	Fibre of #5 plus 10 c.c. Albumin sizing:	33	.08	105.0
7	Fibre of #1 " 10 c.c. " "	41	.135	79.0

Sheets from the First-Run Pulp bleached with Bleaching Powder Solution.

No.	Kind of Sheets.	Lbs. per Sq.In.	Thickness. mm	Per-cent Str.
1	Sheet from pulp as it came from beater:	38	.16	60.5
2	Fibre of #1 bleached with bleaching sol:	32	.19	44.5
3	Fibre of #2 " " more bleaching solution:	42	.25	42.7
4	Fibre of #3 " " " " ing solution:	32	.15	54.3
5	Fibre of #4 " " " " ing solution; until it gave whitest pulp:	15	.13	29.3
6	Fibre of #5 plus 10% $CaCO_3$ plus 10% sizing:	9	.08	28.6
7	Fibre #5 plus 10% $BaSO_4$ plus 10% sizing:	15	.20	19.0

Second Run:

Weight of stock used (air dry) .....12 oz.

Weight of stock used (oven dry, loss 11.6%) .....10.6 oz.

Weight of cooked chips (moist) ..... 1.825 lbs.

Weight of cooked chips (oven dry, loss 74.2%) ... 47 lbs.

Percent of stalks lost during cooking: ..... 29 %

Weight of cooked chips sent to beater (oven dry):.452 lbs.

Weight of first pulp removed from beater: ..... 1.281 lbs.

Weight of 2nd.pulp removed from beater: ..... .835 lbs.

Weight of unbeaten stalks (oven dry) ..... .017 lbs.

Weight of first pulp (oven dry)(loss 83.8%) .... .208 lbs.

Weight of second pulp(oven dry - loss 73%) ..... .224 lbs.

Total weight of material recovered from beater: .449 lbs.

Percent of stalks lost during beating: ..... 2 %.

Percent yield of unbleached pulp = $\frac{.449}{.663}$ = ... 68 %.

Alkali Recovery.

Total Volume of liquor: ---------- 1475 c.c.

1 c.c. of liquor was titrated with $\frac{N}{10}$ H_2SO_4 using phenolphthalein as indicator:

$$1 \text{ c.c. of liquor} = .5 \text{ c.c. } \frac{N}{10} H_2SO_4 .$$

1 c.c. of liquor was titrated with $\frac{N}{10}$ H_2SO_4 using methyl-orange as indicator:

$$1 \text{c.c. of liquor} = 3.6 \text{ c.c. } \frac{N}{10} H_2SO_4.$$

Assuming that in the titration with H_2SO_4 using phenolphthalein as indicator, the H_2SO_4 has reacted with the NaOH present. Also that all of the Na_2CO_3 has been converted during the cooking to $NaHCO_3$ as the water extract of stalk is acid, and that the H_2SO_4 in the titration using methylorange as indicator has reacted with free NaOH and the NaOH present.

Titration with $AgNO_3$ showed that 13.15 gr. of NaCl were recoverable.

Reagents recoverable.

NaOH	-	2.956 gr.	-	28.8% of NaOH used.
$NaHCO_3$	-	38,410 gr.	-	43 % of Na_2CO_3 used.
NaCl	-	13.15 gr.	-	48.2% of NaCl used.

Weight of Pulp taken for one sheet (air dry) ---------- 1.492 gr.

Weight of unbleached sheet ---------- 1.420 gr.

Percent of stalk utilized in making a sheet of paper ------ 65 %

Results of Pulp derived from unbeaten stalks which were beaten to Pulp upon further beating.

No.		Wgt. of Sheet Oven-dry.	Per-cent of stalks used.	Lbs. per Square Inch.	Size in Inch-es.	Per cent Str.
1 x	Sheet made from unbleached pulp:	1.42	65	14	.0067	21
2 x	Pulp of #1 above partially bleached with $KMnO_4$:	-	-	21	.0038	55
3 x	Pulp of #2 bleached with more $KMnO_4$:	-	-	19	.0031	61.5
4 x	Pulp of #3 bleached with more $KMnO_4$:	-	-	32	.0040	80
5	Pulp of #3 bleached with more $KMnO_4$:	-	-	10	.00078	130
6X	Pulp of #1 bleached with $\frac{1}{100}$ lbs. bleaching powder:	1.3	59.2	16	.0076	21.2
7 X	Pulp of #1 bleached with $\frac{1.5}{100}$ lbs. bleaching powder:	1.35	61.5	12	.0064	18.8
8 X	Pulp of #1 bleached with $\frac{2}{100}$ lbs. bleaching powder:	1.25	57.5	5	.0038	13.2
9 X	Pulp of #1 bleached with $\frac{2.5}{100}$ lbs. bleaching powder:	1.28	58.4	7	.0056	12.5
10X	Pulp of #1 bleached with $\frac{3}{100}$ lbs. bleaching powder:	1.15	52.2	6	.0060	10
11 x X	Pulp of #1 bleached with $\frac{3.57}{100}$ lbs. bleaching powder:	1.39	63.0	6	.0060	10
12X	Pulp of #1 bleached with $1\frac{1}{2}$ gr. $KMnO_4$:	1.08	49.0	7	.0034	21
13 x X	Pulp of #1 bleached with 2 gr. $KMnO_4$:	.9	40.8	14	.0027	52
14 x X	Pulp of #1 bleached with $2\frac{1}{2}$ gr. $KMnO_4$:	.7	32.0	4	.0013	30
15 x X	Pulp of #1 bleached with $\frac{2}{100}$ bleaching powder plus 1 gr. $KMnO_4$:	2.2	147	7	.0086	8

x - Samples attached on pages 22 to 24 .

X - 1.492 gr. of stalks in form of moist pulp were treated with the quantity of bleaching agent specified.

Results of Pulp from the First
Beating of Cooked Stalks.

No.		Lbs. per Sq.In.	Size. mm	Per cent Str.
1 x	Sheet made from unbleached pulp:	7.5	.09	21
2	To 12.2 gr.of pulp calculated oven dry added 1 gr. $KMnO_4$:	15.	.14	27.1
3	To 12.2 gr.of pulp calculated " dry added 2 gr. $KMnO_4$:	24.2	.22	27.8
4	To 12.2 gr.of pulp calculated " dry added 3 gr. $KMnO_4$:	51.5	.28	46.9
5	To 12.2 gr.of pulp calculated " dry added 5 gr. $KMnO_4$:	26	.11	59.8
6 x	To 12.2 gr.of pulp calculated " dry added 8 gr. $KMnO_4$:	22.5	.07	81.5
7 x	To 12.2 gr.of pulp calculated " dry added 11 gr. $KMnO_4$:	32	.08	102
8 x	To 12.2 gr.of pulp calculated " dry added 14 gr. $KMnO_4$:	11	.02	140
10x	To 12.2 gr.of pulp calculated " dry added $KMnO_4$ until excess:	7	.06	31

Samples attached on Pages 24 and 25.

Third Run:

Weight of stock used (air dry) ---------- $7\frac{1}{4}$ oz.
Weight of stock used (calculated over dry, loss 11.6%) ---- 6.5 oz.

Weight of cooked chips (moist) ----------16.5 oz.
Weight of cooked chips (oven dry - loss 73%) ---------- 4.45 oz.
Percent of stalks lost during cooking ----------31.50 oz.

Weight of cooked chips sent to beater (oven dry) ---------- 4.0 oz.
Weight of first pulp removed from beater: ----------10.33 oz.
Weight of unbeaten stalks oven dry ---------- 1.36 oz.
Weight of first pulp calculated oven dry ---------- 2.14 oz.
Total weight of material: ---------- 3.50 oz.
Percent of stalks lost during beating: ----------12.5 %

Percent yield of unbleached pulp possible if the stalks were also beaten to pulp: ---------- 56 %

Alkali Recovery.

Total volume of liquor: ---------- 1400 c.c.

1 c.c.of liquor = .3 c.c. $\frac{N}{10}$ H_2SO_4; phenolphthalein indicator.

1 c.c.of liquor = 3.5 c.c $\frac{N}{10}$ H_2SO_4; methyl-orange " .

5 c.c. of liquor = .1693 gr. AgCl.

Reagents recoverable.

NaOH	-	2.38 gr.	-	28.3 % of NaOH
$NaHCO_3$	-	37.53 gr.	-	61.3 % of Na_2CO_3
NaCl	-	19.04 gr.	-	83.5 % of NaCl

Results of Pulp of Third Run.

No.		Wgt. of Sheet Oven-Dry.	Per cent of stalks used.	Lbs. per Sq. In.	Size in Inches.	Per-cent Str.
1 x	Sheet made from unbleached pulp:	1.31	51	10	.0096	10.3
	To 1.44 gr. of dry pulp -					
2	added 1/2 gr. $KMnO_4$:	1.11	43	5	.0053	9.5
3	" 1 gr. "	1.13	44	5	.0015	33.
4	" 1½ gr. "	.84	32	4	.0014	28.5
5	" 2 gr. "	.92	35	5	.0014	35.6
6	" 2½ gr. "	.82	31.8	4	.0012	33.2
7	" 3 gr. "	.82	31.8	3	.0008	37.5
8	" $\frac{1}{100}$ lbs. of bleaching powder:	1.27	49.1	6	.011	5.1
9	" $\frac{1.5}{100}$ lbs. " " "	1.31	51.	5	.007	7.1
10	" $\frac{2}{100}$ lbs. " " "	1.26	49	4	.012	3.3
11	" $\frac{2.5}{100}$ lbs. " " "	1.19	46	5	.008	6.25
12	" $\frac{3}{100}$ lbs. " " "	1.31	51	4	.0046	8.75
13	" $\frac{3.5}{100}$ lbs. " " "	1.14	44.5	-	-	-
14	" $\frac{4}{100}$ lbs. " " "	1.13	44.	8	.0042	19.5
15	" $\frac{1.1}{10}$ lbs. " " "	1.05	40.8	-	-	-
16	x " $\frac{1.1}{10}$ lbs. " " " plus 3/4 gr. $KMnO_4$:	1.25	43.	4	.0036	11.2

x - Samples attached on Page 26.

Fourth Run:

Weight of stock used (air dry) ---------- 10.5 oz.
" " " " (calc.on oven dry, loss 12.1%) ------- 9.1 oz.

Weight of cooked chips (moist) ----------21-1/8 oz.
" " " " (oven dry, loss 63.8%) ---------- 7.7 oz.

Percent of stalks lost during cooking: ---------- 15.3%

Weight of cooked chips beaten in the jar mill ---------- 6.89 oz.

Weight of pulp obtained from Jar I to which 50 gr.of $KMnO_4$ was added: ---------- 8.00 oz.

Weight of pulp obtained from Jar III to which 100 gr.of $KMnO_4$ was added: ----------4-3/8 oz.

Weight of pulp obtained from Jar II to which no bleaching agent was added: ---------- 7.5 oz.

Weight of unbeaten stalks from Jar II oven dry: ---------- .5 oz.
Weight of pulp from Jar I oven dry: ---------- 1.08 oz.
Weight " " " " III " " : ---------- .95 oz.
Weight " " " " II " " : ---------- 1.24 oz.

Total pulp accounted: ---------- 3.77 oz.

Percent of stalks converted to pulp: ----------48.4 %

Alkali Recovery.

Total volume of liquor : ----------1750 c.c.

1 c.c.of liquor = .15 c.c. $\frac{N}{10}$ H_2SO_4 - phenolphthalein indicator.

1 c.c. " " =4.3 c.c. $\frac{N}{10}$ H_2SO_4 - methyl-orange ".

5 c.c. " " = .0663 gr. AgCl.

Reagents Recoverable.

NaOH	-	1.05 gr.	-	6.3 % of NaOH
$NaHCO_3$	-	61.0 gr.	-	31.2 % of Na_2CO_3
NaCl	-	9.45 gr.	-	69.5 % of NaCl

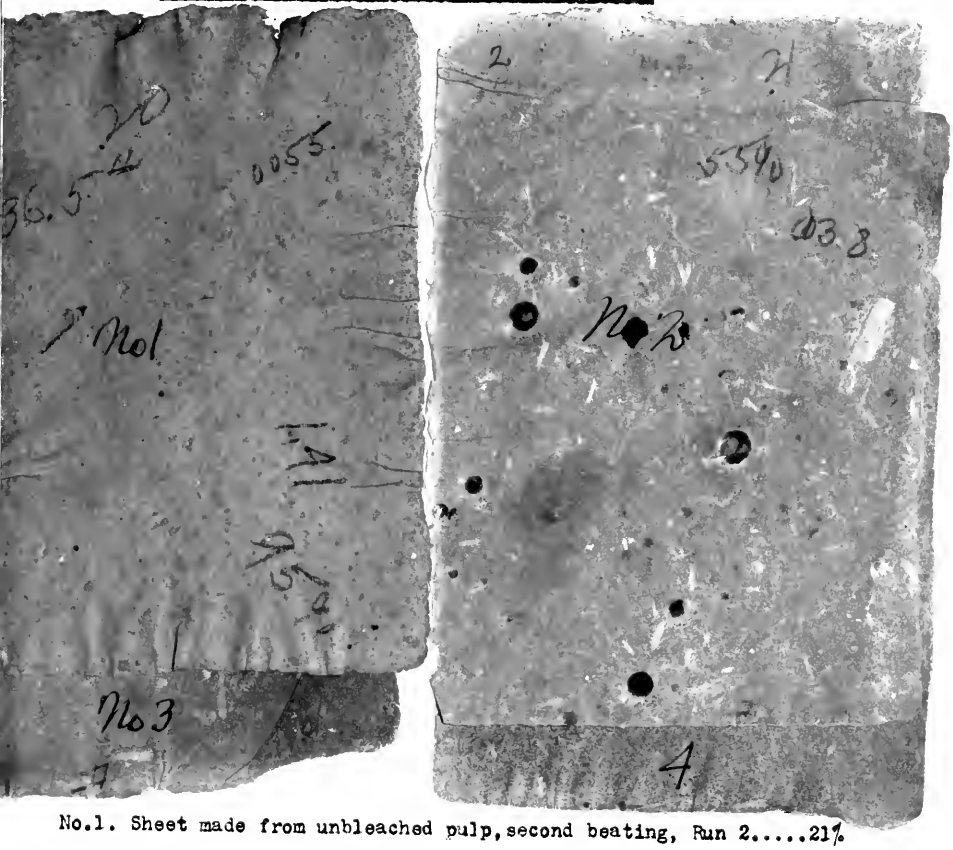
Sheets made from unbleached pulp are .....19 % strong. x

Sheets made from bleached pulp, bleached by adding 50 gr. $KMnO_4$ to the jar are..... 64% " x

Sheets made from pulp which was bleached with 100 gr. $KMnO_4$ are brittle and fall to pieces.

x - Samples attached to pages 25 and 26.

Samples from Pulp of Second Run obtained from second beating of stalks.



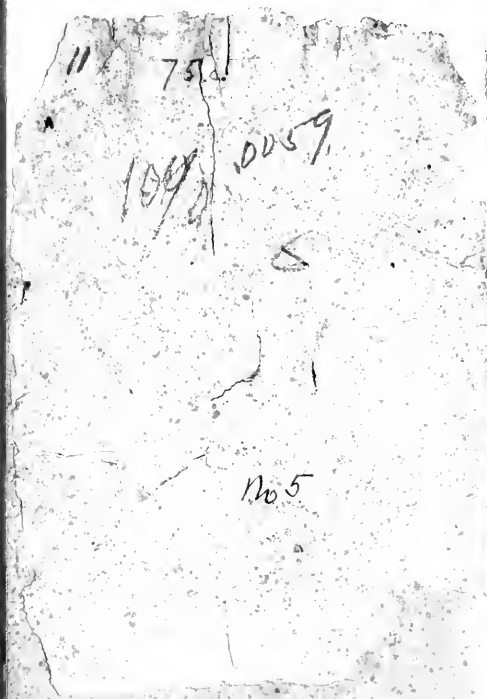
No.1. Sheet made from unbleached pulp, second beating, Run 2.....21%

No.2. " " " #1 pulp, partially bleached with $KMnO_4$ 55%

No.3. " " " #2 " , bleached with more $KMnO_4$ 61.5%

No.4. " " " #3 " , " " " $KMnO_4$ 80%

Samples from Pulp of Second Run obtained from second beating of Stalks. Cont'd.

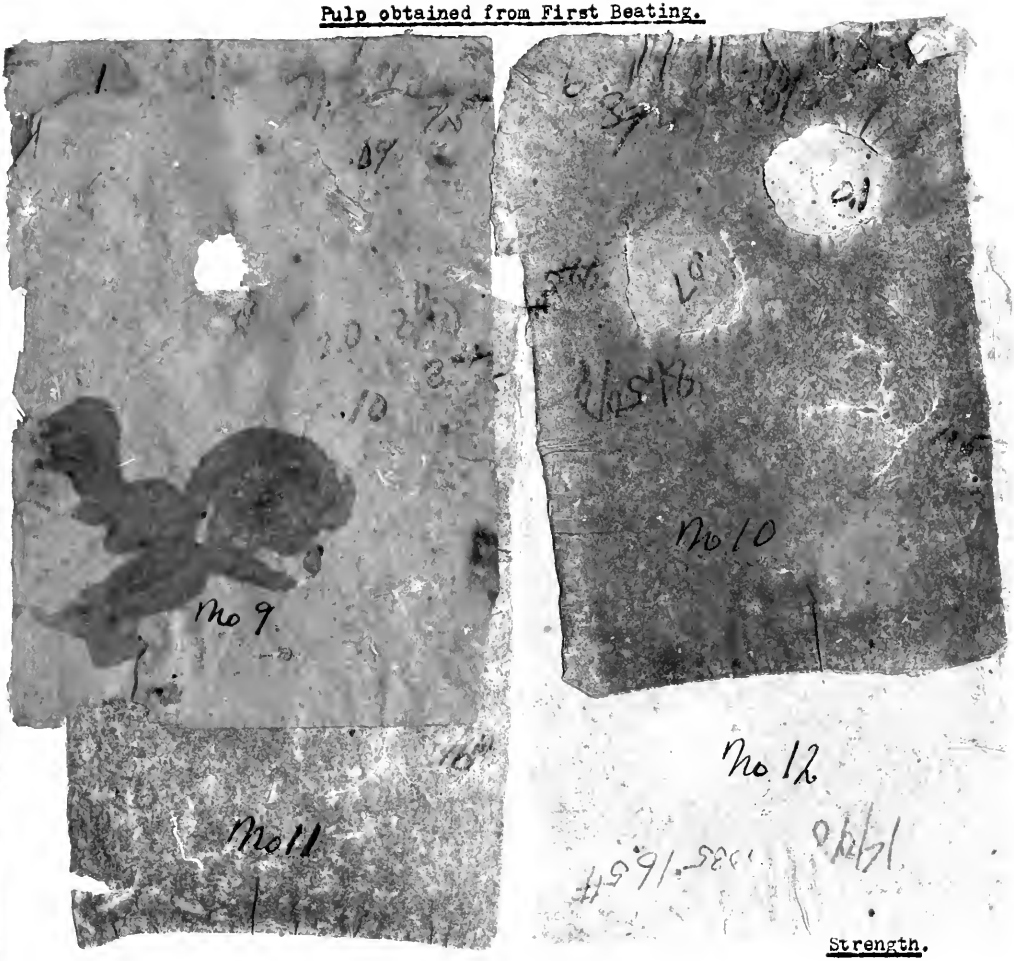


No 7

No 8

		Strength.
No.5.	Sheet made from #1 pulp bleached with $\frac{3.57}{100}$ lb. bleaching powder:.....	10%
No.6.	" " " #1 " " " 2 gr. $KMnO_4$	52%
No.7.	" " " #1 " " " $2\frac{1}{2}$ gr. $KMnO_4$	30%
No.8.	" " " #1 " " " 1 gr. $KMnO_4$ and 2/100 lbs. bleaching powder:	8%

Pulp obtained from First Beating.



Strength.

No.9. Sheet made from unbleached pulp 21%

No.10. " " " 12.2 gr.of pulp bleached with 8 gr.$KMnO_4$ .. 81.5%

No.11. " " " 12.2 gr. " " " " 11 gr.$KMnO_4$ .. 102%

No.12. " " " 12.2 gr. " " " " 14 gr.$KMnO_4$ .. 140%

Pulp obtained from First Beating.
Continued.

Strength.

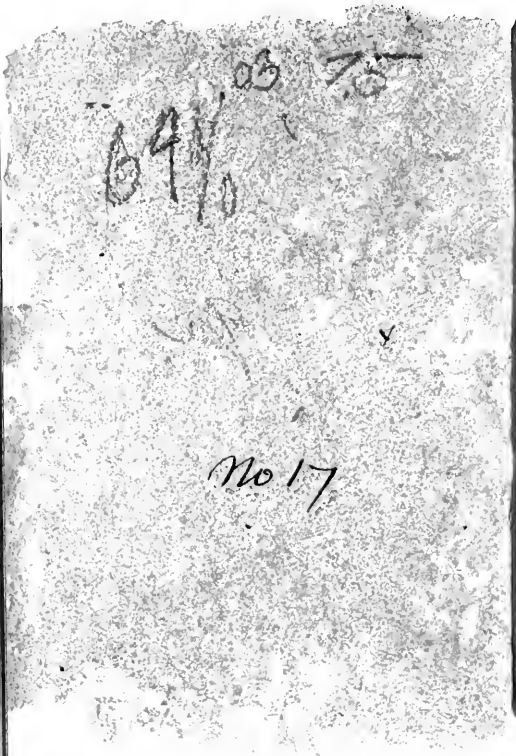
No.13. Sheet made by bleaching 12.2 gr.of pulp of Sample #9 with $KMnO_4$ till solution became violet: 31%

No.14. Sheet made from unbleached pulp of third run :.....10.3%

No.15. Sheet made from 1.44 gr.of pulp of third run bleached with $\frac{1.1}{10}$ lbs.bleaching powder plus 3/4 gr.KMnO4 .....11.2%

No.16. Sheet made from unbleached pulp of fourth run: 19%

Pulp obtained from First Beating.
(Continued.)



No.17. Sheet made from Pulp bleached by adding 50 gr.of $KMnO_4$ into the jar while the stalk was beaten to a pulp: 64%

No.18. Sheet made from Pulp of run No.1: 63.5%

DISCUSSION.

From the results obtained I believe that we could get better grade of paper from green stalks than from natural dried stalks. By bleaching the pulp the strength is increased to a certain point and then it decreases with the addition of the bleaching agent. This can be best seen from results of first and second run. The best cooking pressure is between 70 and 100 lbs. per square inch. When the stalks were cooked at a pressure higher than 120 lbs. per square inch the fibres were destroyed, as it is well shown by the results of the third run. The addition of sizing increases the strength of the sheets.

The lumps in the sheets could be avoided if the sheets were made from pulp as it came from the beater; but as the yield had to be determined the water had to be squeezed from the pulp. By squeezing the water from the pulp the fibres were brought so close together that upon diluting with water they could not be broken up.

From results obtained it is evident that the pulp can not be bleached with bleaching powder, chlorine, under the conditions the bleaching was tried.

The pulp can be bleached with $KMnO_4$, but the bleaching will not be economical. Parchment paper can be made from the

pulp by bleaching the pulp with $KMnO_4$.

From the data at hand the sunflower stalks can be used only for the manufacture of unbleached paper, such as wrapping paper or craft paper.

PART II.

This chapter deals with the proposed process and giving an idea of the cost of operation.

The Proposed Process.

The sunflower stalks are cut when they are fresh and green, a few weeks before they begin to dry out. They are to be dried in a steam heated closet, and when they are dry, they are to be shredded. The shredded material is to be cooked with the following cooking mixture:

NaOH	- 5% of	weight	of	stalks	used.
Na_2CO_3	- 10% of	"	"	"	"
NaCl	- 8% of	"	"	"	"
NaOCl	- .25% of	"	"	"	"

Liquor drained from stalks.

The material is to be cooked in a steam-heated kettle at a pressure of 70 to 90 lbs.per sq.in. The cooking will be accomplished in ten hours.

The cooked material is to be beaten in a jar-mill until the fibres are separated. The stalks placed into the mill shall be five to ten percent by volume of the pebbles used. The jar shall be only one-third full filled with pebbles, and enough water added to cover the pebbles and the stalks.

If the pulp is to be bleached the bleaching agent shall be added to the pulp in the mill just before it is ready to be removed. Pulp shall then be treated according to the present practice of making paper from the pulp.

C o s t.

Original Investment, including buildings and complete equipment: $200,000.00

Running Expenses per Day.

Man in charge of Fourdrinier Machine:	$6.67	
Two assistants to above, each $20.00 a wk: ..	6.67	
Cost of one shift:	$13.34	
Cost, two shifts:		$26.68
Man in charge of Beaters:	$4.17	
Two assistants to above, each $2.25 a day: ..	4.50	
Two laborers: .. " $1.75 " " ...	3.50	
Total per shift:	$12.17	
Cost, two shifts:		$24.34
Man in charge of Cookers:	$4.17	
Two laborers: $1.75 a day:	3.50	
Cost per shift:	$7.67	
Cost, two shifts:		$15.34
Man in charge of Boiler Room:	$4.00	
One laborer :	1.75	
Cost per shift:	$5.75	
Cost, two shifts:		$11.50
General Sup't:		$20.00
One (1) Chemist:		5.00
Office Force:		$10.00
Total Cost Labor per Day:		$ 112.86

Cost of Material.

50 tons of raw material at $5.00, at plant	$250.00
Sodium-hydroxide (NaOH) .05 x 100000 x 2:	100.00
Sodium-Carbonate (Na_2CO_3) .1 x 100000 x .6 :	60.00
Sodium-Chloride (NaCl) .08 x 100000 x .0075	60.00
Sodium-Hypochloride (NaOCl) .0025 x 100000 x .0725 ...	16.13

Sizing:

1890 lbs. Rosin	at 1.35¢ per lb.	$ 25.66
360 lbs. NaOH	" .02¢ " "	7.20
250 lbs. $Al_2(SO_4)_3$	" 1¼¢ " "	3.13

Other Charges.

Interest at 6%	$33.34
Depreciation at 6%	33.34
Taxes:	2.78
Insurance:	2.78
Coal:	50.00
Total Cost:	$759.22

Total paper produced .....50,000 lbs.

Cost of Unbleached Paper: Per Lbs: .....1.52 cts.

Cost of Light Yellow Paper:

Cost of Unbleached paper .....1.52 cts.
50% of wgt.of pulp, $KMnO_4$ as bleaching
agent: .....5.00 cts.

Cost of light yellow paper: 6.52 cts. per lb.

Cost of White Paper:

1.66 lbs.of unbleached pulp required
to make 1 lb. bleached ..... 2.52 cts.per lb.

100% of wgt.of pulp, $KMnO_4$ as bleaching
agent: ..... 9.75 cts. " "

Cost of white paper: 12.27 cts. per lb.